A NIFTI Solution to Far-Field Antenna Transformations

Windie Borodin and Danielle King
Midway Research Center

The Near Imaging Field Tower Implementation was developed to provide a mid-range system that performs far-field characterization of several 60-foot antenna systems. The challenge was to take a highly complex development effort and bring it in on time and within cost. This article describes the team's success using an object-oriented design under a tailored IBM Rational Unified Process and established metrics to monitor the progress.

The mission of the Midway Research Center (MRC) located in Stafford, Va., is to function as a high-precision signal source for calibrating and testing national and tactical systems. Among its numerous assets are three antennas 60-foot in diameter that provide highly accurate radio frequency (RF) signals. Due to their size and location, they require a system to characterize the antennas to be located as much as 25 miles away from where they are actually located. This type of system requires aircraft to accomplish this task, making it economically impossible to characterize the antennas on a regular basis.

The U.S. Navy decided to develop a mid-range calibration system approximately 884 feet away from the antennas to transform the RF data from the antenna into a pattern that makes them appear 25 miles away. This is known as the Near Imaging Field Tower Implementation (NIFTI) project. The goal was to produce an operational system that could be used on a regular basis to collect data from the test signal being transmitted from the antennas. By analyzing this data, the system would be able to determine what factors are needed to correct the actual signal being transmitted. This would produce a better quality and higher precision signal being transmitted to the desired targets.

The system was developed and tested using the Antenna Tracking Subsystem (ATS)-3 antenna. This antenna scans across a reflector that is mounted at the calibration tower. Data is collected as the ATS-3 antenna generates a continuous wave tone and scans across the calibration tower. This data is then transformed into a far-field pattern using a Fourier transform technique, a method for analyzing periodic functions.

NIFTI Team

The core development team was located on site with the system user and was comprised of both government and contractor personnel. Within the development, tasks were distributed among numerous contractors, including Mnemonics, Inc.; Assurance Technology Corporation; Harris Corporation; Blazeware; Analex; and Science Applications International Corporation. The project overcame challenges inherent when different companies work side-by-side such as corporate alliances and company policies. It also tackled the required knowledge of both RF theory and software engineering.

Those chosen for the task ranged in experience from interns to Ph.D.s. Expertise in different areas was shared among team members. Junior level software engineers trained senior level personnel on programming best practices and software engineering principles, while the senior level personnel trained others on RF theory. This coordination provided for maximum use of resources and overall team strength.

Developing alongside the ultimate system user also aided project success. The NIFTI team established processes (i.e., document and code reviews, risk management, configuration management, and training) that engaged the customer (U.S. Navy) and the end user (MRC operators) in the design and development process. These processes required the end user to be an active participant in the development effort. The end user participated in all document reviews, user interface working groups, all system integration, and acceptance testing.

The project team established a training process with the end-user software maintenance group where the software maintainers became part of the development team to learn and understand the software before it was delivered. The end user also held a seat on the Configuration Control Board and was able to generate change requests against the system at any time during the development process. This allowed the end user and customer the ability to provide input into the design and determine what changes were important.

Before this effort began, the end user was trained along with the developers on any new tool or process that was being used during the development. The team collected metrics on process, performance, change requests, budget, and schedule. These were provided at every design review to the customer and end user. This kept the customer informed about the project's progress. It also established a close working relationship, which allowed for the end user/customer to be involved in every major step of the development process.

Software Development

The NIFTI project was developed using object-oriented design and a tailored IBM Rational Unified Process. A development suite was established consisting of the Rational Suite of software that included ClearCase, ClearQuest, Requisite Pro, Rose, Test Manager, and McCabe Quality Toolset. A combination of UNIX (Sparc processors) and Windows (PC)-based servers were used to house the development environment.

The project followed the inception, elaboration, construction, and transition phases. In the inception phase, the budget and high-level schedule were established and the requirements were analyzed. As part of performing requirements analysis, all stakeholders met to come to an understanding of the requirements. Once this was accomplished, the requirements were then placed into Requisite Pro (a requirements tracking tool). Each requirement was assigned attributes such as (1) build that the requirement was to be implemented, (2) asset for which the requirement was needed, (3) use case that contained the requirement, and (4) test case it was assigned. Also contained in the database was an interpretation of the requirement that clearly explained the intent, which was agreed to by all stakeholders.

The end of the inception phase was designated by a review to the customer and end user. At this review, the team pre-

sented the project overview, system concept, external boundaries of the system being designed, software standards, requirements, acceptance criteria and verification matrix, and project risks.

For the elaboration and construction phases, an iteration plan was developed along with a schedule for that phase. The iteration plan contained what the team was going to accomplish during that phase along with evaluation and exit criteria, and the requirements that were to be addressed. At the end of each phase, the team provided a review to the customer and end user. During the elaboration phase, the team focused on prototyping some of the high-risk areas in the software. The main items presented during the end-of-phase review were system overviews, prototype results, use cases, test plans, refined software estimates, defined architectures, requirements mapped to use cases, requirements mapped to construction iterations, structured software models, schedules, and risks.

The construction phase was divided into three builds, with each build being four to six months in duration. One obstacle the project faced was that the NIFTI system was being installed into an operational system, thus the system was not always available for testing some requirements. When this occurred, the requirement was deferred until the next build and a requirement initially slated for a later build was implemented in its place. During the build, the tester conducted usability tests with the end user that gave him the opportunity to use the system. Feedback was given to the developers so that required changes could be made. This helped produce a system that was user-friendly and met the end user's needs.

The reviews at the end of each build were assessments of how the project performed during that build and whether the project accomplished the goals contained within the iteration plan. It also included a presentation of the metrics gathered not only during the build, but also during the project life cycle. During the end-of-build presentation, a demonstration of the system was also given to the customer. The unique thing about the demo was that it was run by the end user. This demonstrated to the customer that the end user was part of the team and that their needs were being addressed. Also presented at the review were the plans for the next build along with any updated schedule or project risks.

The transition phase consisted of a Developers' Test and Evaluation and formal installation of the system into the operational asset. The testing was wit-

Members of the Near Imaging Field Tower Implementation team are, from left, (front row) Steve Rugari, Pauletta Morrast, Warren Wagner, Greg Dye, Windie Borodin, Alice Howell, Terry Arbnot, Tom Shea, (back row) Susan Dilbeck, Norman Byrne, Danielle King, George Williams, Mark Lucas, Mike Whitelaw, Josh Howell, and Jim Dye.

nessed and signed off on by personnel from the site's Systems Engineering Department; also present were personnel from the operations staff – the eventual system user.

Project Monitoring

The NIFTI project was monitored by using these established metrics:

1. **Cost measurements.** Within budget.
2. **Schedule performance.** Within an 18-month development cycle.
3. **Assessment measurement.** Produced 12 source lines of code (SLOC) per day versus the seven SLOC industry standard.
4. **Open/closed convergence of defects.** Number of open defects converged with closed defects.
5. **Hours expended per defect.** Most defects were repaired in less than three hours.
6. **SLOC per defect.** Most defects were repaired in less than 10 lines of code.
7. **Defects per subsystem inspection and testing (I&T) versus system I&T.** Most defects were detected during subsystem I&T before being delivered to the testers.

The team also monitored the software to evaluate it in terms of complexity (all modules had a complexity of 10 or less using McCabe Tools), to check for memory leaks, to determine bottlenecks, and to test path coverage.

Summary

The innovative processes that incorporated the end user and customer throughout the software development process have proven to be key in achieving project suc-

cess. These structured processes, risk mitigation, metrics, and close communication with the end user/customer have been instrumental in producing a quality product on time and within budget that met its requirements. The diverse backgrounds of the development team also proved to be instrumental in the success of the project.

Major benefits from the system were seen even before it was officially turned over to operations: It has been used to detect a feed offset and bore sight problem in the ATS', and to find a software problem that caused antenna tracking to be off in customer tests. The clients were grateful that these and other problems could now be identified and resolved much faster and easier than before.◆

Project Points of Contact

Windie Borodin
Midway Research Center
Naval Research Laboratory
635 Telegraph RD
Stafford, VA 22554
Phone: (703) 551-1992
Fax: (703) 221-3317
E-mail: borodin@kingcrab.
nrl.navy.mil

Danielle King
Midway Research Center
Naval Research Laboratory
635 Telegraph RD
Stafford, VA 22554
Phone (703) 551-1975
Fax: (703) 221-3317
E-mail: king@kingcrab.nrl.navy.mil